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Device and process for measuring luminous intensity by means of a photomultiplier equipped with a calibration source

The invention relates to the measurement of luminous intensity by means of photomultipliers.

The gain of a photomultiplier is subject to short-term fluctuations, such as those resulting from variations of the temperature of this photomultiplier, and to long-term fluctuations or drifts, such as those resulting from wear and aging of this photomultiplier.

These fluctuations or drifts of the gain introduce errors into the measurements delivered directly by the photomultiplier. This is the case in particular for the camera described in European Patent 0066763, which is equipped with a pulsed calibration source and which measures continuous radiation.

The purpose of the invention is to avoid this disadvantage.

To this end, one object of the invention is a device for measuring the luminous intensity of radiation, comprising a photomultiplier equipped with a main window for entrance of the said radiation and an entrance cathode disposed in the field of the said window, characterized in that it also comprises a calibration source designed to emit radiation of constant intensity oriented toward the said photocathode.

The invention can also exhibit one or more of the following characteristics:

- the said calibration source is an electroluminescent diode,
- the wavelength of the maximum emission intensity of the said diode falls within the wavelength region of maximum sensitivity of the said photomultiplier,
- the device comprises a scintillator element disposed across the main entrance window and designed to convert the radiation to be measured to radiation of wavelength matched to the sensitivity of the said photomultiplier, the calibration source emitting directly toward the said photocathode without passing through the scintillator.

Since the scintillator element is generally not subject to any fluctuation or drift, the calibration radiation can be applied directly to the photomultiplier without passing through the scintillator.

Another object of the invention is a device for measuring the interaction of radiation with a material, comprising a primary source of

radiation between the said primary source and the said measuring device.

The said primary source of radiation can be an X-ray source.

Preferably the device according to the invention also comprises:

- means for turning off the source of radiation or for blocking the radiation to be measured,
- means for activating the said calibration source exclusively during the periods when the said radiation is turned off or blocked,
- and means for calculating the ratio of the measurement performed by the photomultiplier subjected to the radiation to be measured during a period when this radiation is not turned off or blocked to the measurement performed by the photomultiplier under the same conditions during a period when the calibration source is activated.

In the case of an X-ray source, there is preferably used a pulsed X-ray source to ensure that the said source is periodically turned off; preferably this pulsed source then comprises an X-ray emission tube provided with a filament, an anode and a cathode, plus means for applying a high alternating voltage between the said anode and the said cathode.

Such an X-ray source is sturdy and economical.

Another object of the invention is a process for measuring the luminous intensity of radiation by means of the device according to the invention, wherein the ratio of the measurement of the radiation to be measured to that of the radiation of the calibration source is calculated; more precisely, this process comprises the successive stages in which:

- while the calibration source is turned off or blocked, the intensity of the radiation to be measured is measured by means of the photomultiplier,
- thereafter, while the radiation to be measured is turned off or blocked, the intensity of the radiation of the calibration source is measured by means of the photomultiplier maintained under the same adjustment conditions,

- and the final value of the intensity of the radiation is deduced by calculating the ratio of the measurement of the radiation to be measured to that of the radiation of the calibration source.

Finally, another object of the invention is the use of the device or of the process according to the invention for measuring the thickness of a material interacting by absorption with the said radiation to be measured.

The invention will be better understood by reading the description hereinafter, given by way of non-limitative example and with reference to the attached figures, wherein:

- Fig. 1 is a simplified diagram of a device for measuring material thickness, comprising the device for measuring luminous intensity according to the invention,
- Fig. 2 is a diagram of the successive measuring sequences of the process according to the invention,
- Figs. 3A and 3B are simplified electrical schematics of pulsed and continuous X-ray sources respectively.

According to this non-limitative description, the invention is employed in a device for measuring the thickness of a material 3; the thickness measurement is based in classical manner on measurement of the absorption of radiation by this material.

The device for thickness measurement comprises a primary source 1 of radiation, a device 2 for measuring the luminous intensity of the radiation that has interacted by absorption with material 3, and means, not illustrated, for disposing material 3 in the path of the radiation between primary source 1 and measuring device 2.

Measuring device 2 is equipped with a photomultiplier 4.

Photomultiplier 4 is equipped in classical manner with a main window for entrance of the radiation to be measured and an entrance photocathode, not illustrated, disposed in the field of the said window.

According to the invention, measuring device 2 comprises a calibration source 5 designed to emit radiation of constant luminous intensity oriented toward the photocathode.

In classical manner, this device 2 is also equipped with means 6 for preamplification and coding of the signal delivered by photomultiplier 4, and decoding means 7 connected both to preamplification means 6 and calibration source 5.

If material 3 is opaque to visible radiation, there is used as primary source 1 an X-ray source which emits in a wavelength region suitable for measurement of the thickness of this material; since photomultipliers are generally not very sensitive for detection of X-rays, photomultiplier 4 is equipped with a scintillator element 8 disposed across its main entrance window and designed to convert the radiation to be measured to radiation of wavelength matched to the sensitivity of the photomultiplier.

It is noted that the calibration source is disposed such that it emits directly toward the photocathode of photomultiplier 4, without passing through scintillator 8.

Referring to Fig. 3A, there is preferably used as primary source 1 a pulsed X-ray source, which comprises an X-ray emission tube 1 - or "X" tube - equipped with a filament, an anode and a cathode, plus means for applying a high alternating voltage between the said anode and the said cathode: Fig. 3A represents the schematic of such a pulsed source, without rectifier in the high-voltage circuit, in contrast to the schematic of a continuous source, represented in Fig. 3B, which is provided with a rectifier in the high-voltage circuit.

The pulsed mode of emission of this source advantageously forms means for periodically turning off primary radiation source 1.

As calibration source 5 there is preferably used an electroluminescent diode.

Finally, measuring device 2 comprises means for activating calibration source 5 exclusively during the periods when radiation source 1 is turned off, and decoding means 7 are designed to calculate the ratio of the measurement performed by photomultiplier 4 subjected to the radiation to be measured during an emission pulse of primary source 1 to the measurement performed by photomultiplier 4 under the same conditions during

a period of emission of calibration source 5.

The process for use of the invention will now be described.

Referring to Fig. 2, the following two sequences of measurement of luminous intensity take place in alternation:

- during the positive (+) alternation of supply of the "X" tube, corresponding to emission by source 1 (phase B in the diagram of Fig. 2), calibration source 5 does not emit and is turned off, and the intensity of the radiation emerging from this source 1 through material 3 is measured by means of the photomultiplier,
- then, during the negative (-) alternation of supply of the "X" tube, corresponding to the inverse alternation of anode-cathode polarization in which source 1 does not emit and therefore is turned off (phase C in the diagram of Fig. 2), calibration source 5 emits ("on" mode), and the intensity of the radiation from calibration source 5 is measured by means of the photomultiplier maintained under the same adjustment conditions.

Decoding means 7 are designed to separate the signals delivered by the photomultiplier during phases B (measurement proper) and the signals delivered by the photomultiplier during phases C (calibration).

The final values of intensity of the radiation are deduced by calculating the ratio of the measurements of radiation made during phases B to those made during phases C.

Advantageously, the values obtained are then independent of fluctuations or drifts of the photomultiplier.

Preferably the temperature of the electroluminescent diode is stabilized in a temperature range in which its emissivity is the most stable and the most independent of temperature.

The thickness of material 3 is then deduced in a manner known in itself from the obtained values of radiation intensity.

The device for measuring radiation according to the invention can be used for

extremely diverse applications which extend well beyond the field of measurement of material thickness or the field of X-ray wavelengths.

During warmup of an X-ray gauge, or in the event of malfunction, the device for measuring radiation intensity according to the invention makes it possible to recognize the influence of parasitic signals on the measurement delivered by the photomultiplier.

By stopping the "X" emission source as described hereinabove and activating only the calibration source, it is then very easy to detect such parasitic signals and to make modifications to desensitize the installation as necessary (modification of the zero settings, shields and grounds, for example).

The device and the process according to the invention therefore make it possible to monitor the "receiving" section of an installation independently of the "emitting" section.

Moreover, numerous instruments use detectors of the photomultiplier type equipped with scintillators, especially the classical X-ray gauges; referring to Figs. 3A and 3B, the invention makes it possible, without interrupting the measurement of luminous intensity, to take particular advantage of pulsed emission gauges, which are by far the most reliable because of the simplicity of their X-ray source, which is composed (Fig. 3A) merely of a filament-heating transformer, of a high-voltage transformer for direct supply of the tube between anode and cathode, and of the "X" tube itself. A continuous source comprising rectification and possible filtering by a capacitor (Fig. 3B) would not have made it possible to use the invention as simply and economically, and the device obtained would have been less reliable.